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Briggs, Jr. et al.

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[54] **VARIABLE ORIFICE PLATE FOR COAL PIPES**

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[51] **Int. Cl.**[6] **F16K 51/00**

[52] **U.S. Cl.** **251/117**; 251/305

[58] **Field of Search** 251/117, 305; 137/630

[56] **References Cited**

U.S. PATENT DOCUMENTS

1,477,824	12/1923	Grindle	110/265
1,708,496	4/1929	Clendon	431/188
2,079,420	5/1937	Nielsen	110/104 B
2,676,604	4/1954	Senna	251/117
3,002,472	10/1961	Miller	110/106
4,459,922	7/1984	Chadshay	110/265
5,342,019	8/1994	Braun et al.	251/305

Primary Examiner—Noah P. Kamen
Attorney, Agent, or Firm—Mason, Kolehmainen, Rathburn & Wyss

[57] **ABSTRACT**

A flow control apparatus for a coal pipe containing a stream of primary combustion air carrying pulverized solid fuel particles, includes a frame sealingly secured to an outside surface of the coal pipe around a window opening formed on one side of the pipe. An orifice plate having an orifice opening at the center is supported for pivotal movement in the coal pipe on a spindle extending radially outwardly from an edge portion on one side of the orifice plate and out through the window opening in the pipe. A bearing sleeve is provided for supporting the spindle for rotating movement about a spindle axis extending transversely of the coal pipe across the center thereof. A mounting plate structure for the sleeve is provided and is attached to the frame. A removable handle is attached on an outer end of the spindle for rotating the orifice plate in the coal pipe to vary the effective flow cross-section of the orifice opening for controlling the flow of coal and primary air to a burner.

11 Claims, 2 Drawing Sheets

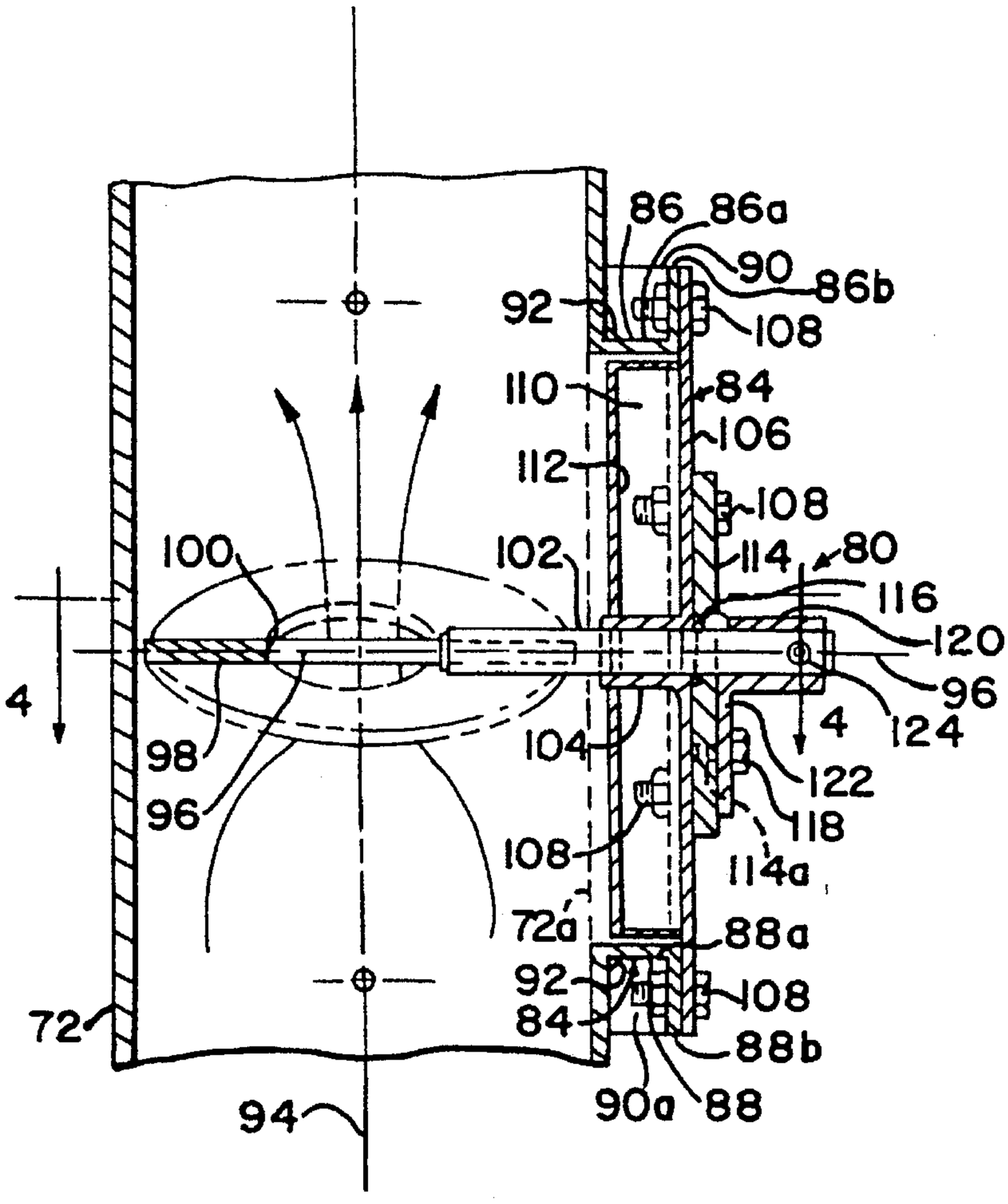

FIG. 1

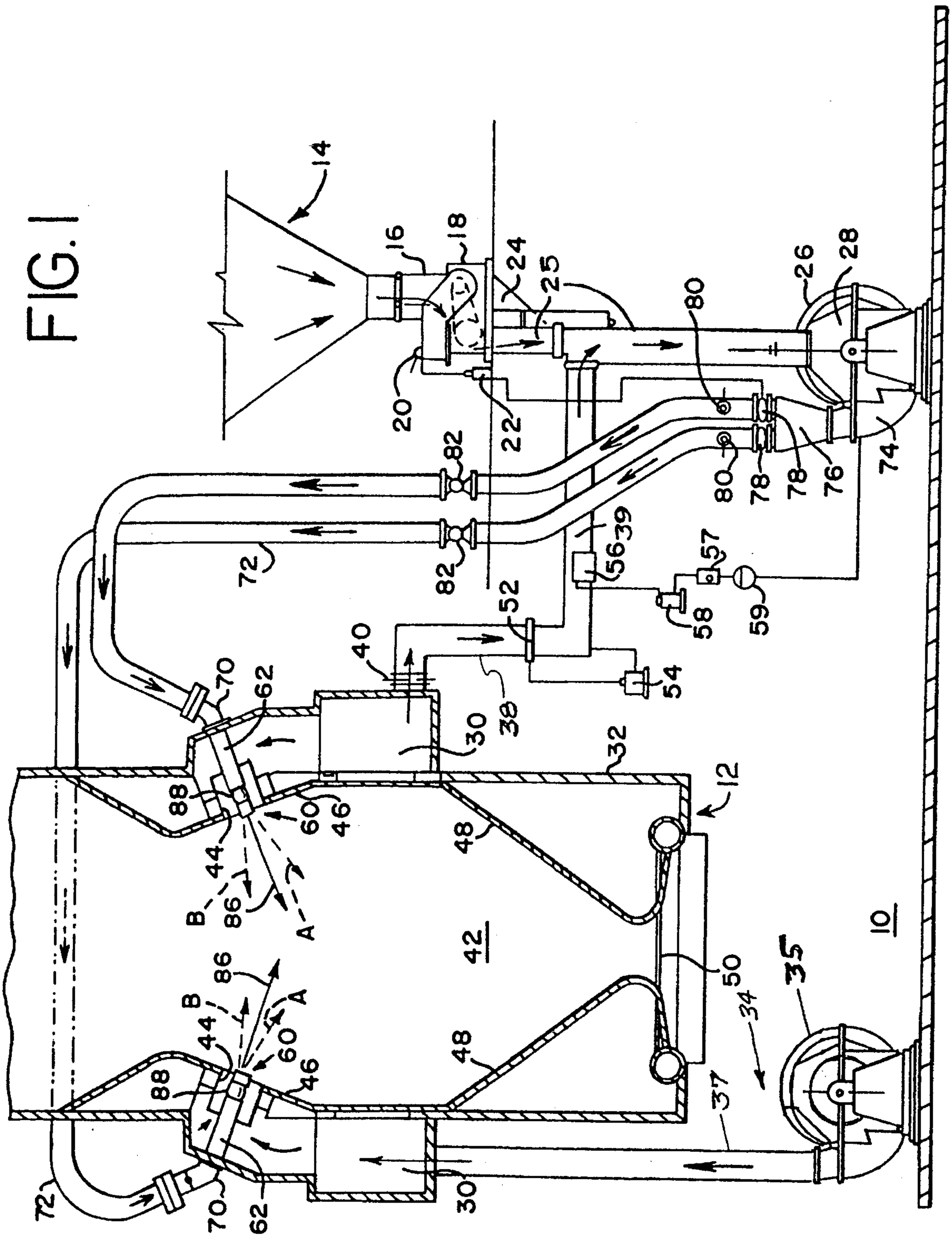
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FIG. 4

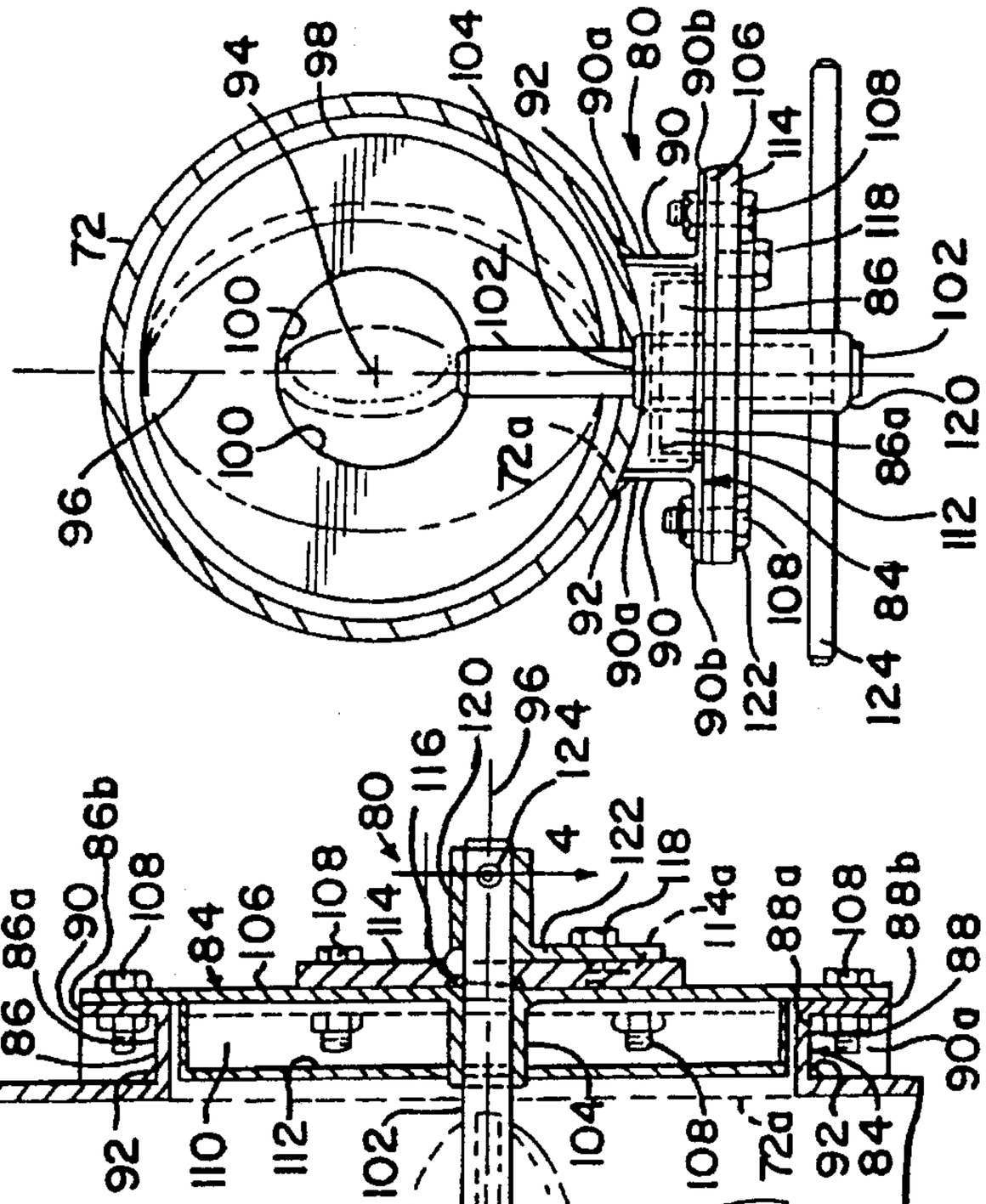

FIG. 3

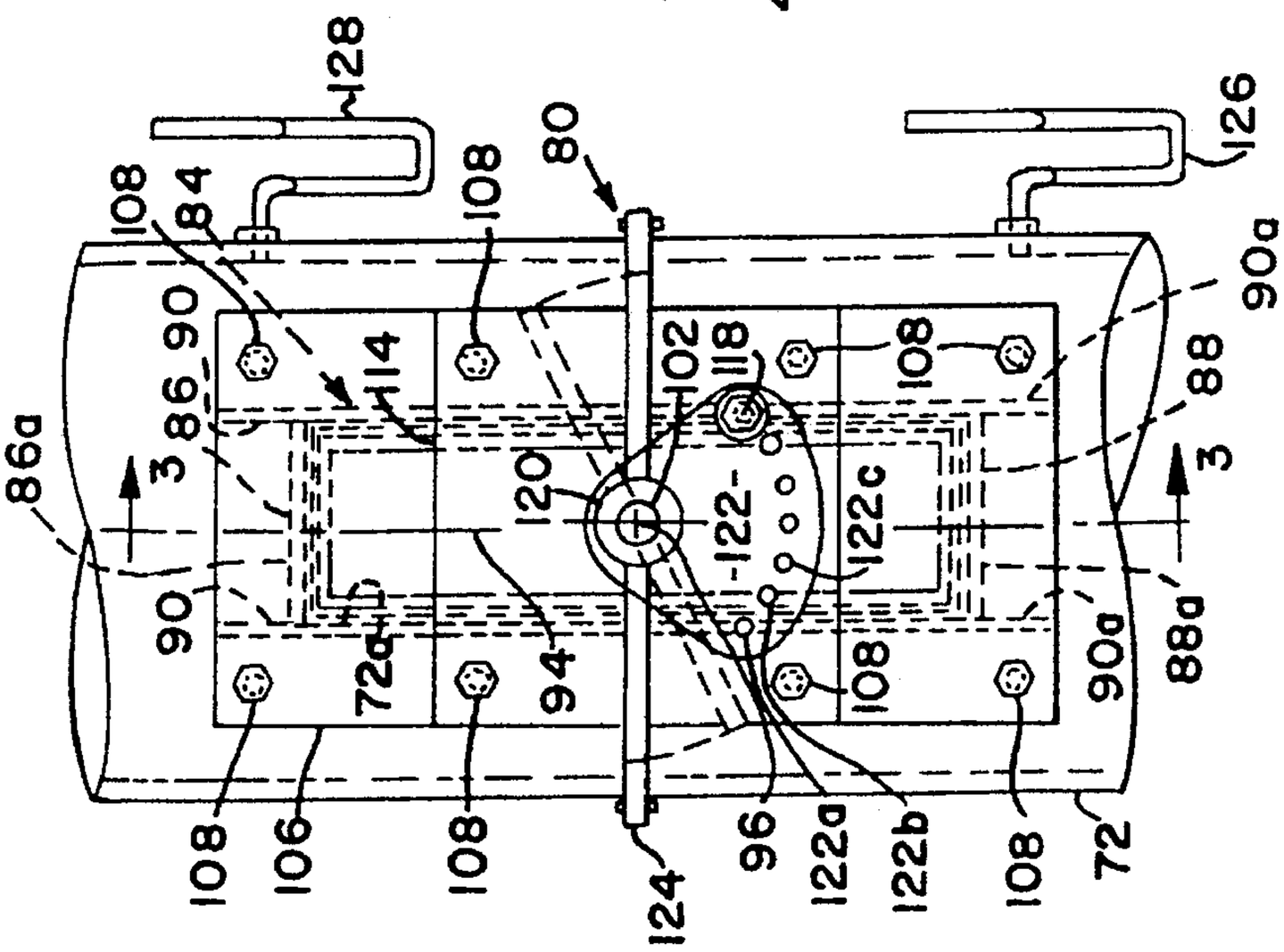

FIG. 2

VARIABLE ORIFICE PLATE FOR COAL PIPES

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a new and improved variable orifice plate for controlling the flow in coal pipes supplying burners in furnaces and boilers. More particularly, the present invention is directed to an orifice plate mounted in a coal pipe and movable between alternate positions to vary the effective flow cross-section for controlling the flow of primary coal and air to a burner. By adjusting the angle of tilt of the orifice plate relative to the general direction of flow along a coal pipe, the effective flow cross-section through the orifice opening is varied and adjustments can be made while on-line during operation of a burner so that the effects of position settings are rapidly available and easily tabulated without requiring the burner to be shut down. 2. Background of the Prior Art

There has been an historical problem of obtaining balanced pulverized coal flow in multiple coal pipe distribution systems. Typically, coal pipes are manifolded from the discharge of a pulverizer. A manifold can be in the form of a classifier, a flow splitter or a riffle box. Previously, a method used to equalize coal flow to each burner was to throttle each coal line to obtain equal pressure drops through all of the multiple coal lines. Because of the nature of two phase flow, including solid pulverizer coal and primary air, several iterations of throttling action were often required to obtain even a temporary coal line balance of plus or minus 10% of the average flow rate in each pipe. Because of the increased need to maintain good coal flow with low NO_X firing, typical previous trial and error methods have not worked.

A new and improved variable orifice plate for coal pipes in accordance with the present invention is useful in a wide variety of pulverized coal supply systems having multiple coal pipes and is especially well adapted for use in systems for supplying multiple burners of all types of furnaces including "TURBO" furnaces such as that shown and described in U.S. Pat. No. 4,517,904, incorporated herein by reference and sold by the assignee herein under the trademark "TURBO" $_R$.

U.S. Pat. No. 1,477,824 discloses a powdered material firing apparatus employing cylindrically-shaped air valve positioned upstream from the point of coal introduction into the stream.

U.S. Pat. No. 1,708,496 discloses a pulverized fuel burner employing rotatably mounted solid circular damper disks in separate fuel and air conduits connected to supply the burner.

U.S. Pat. No. 2,079,420 discloses a burner for firing furnaces with pulverized coal wherein a pair of semi-circular-shaped valves are provided at the inlet end of the burner for dividing the flow between separate nozzle sections.

U.S. Pat. No. 3,002,472 discloses a comminution system for wet solid materials (coal) including generally circular dampers in coal and air pipes feeding a steam generating unit.

U.S. Pat. No. 4,459,922 discloses an externally adjustable pipe orifice assembly employing pivoted plates.

OBJECTS OF THE INVENTION

It is an object of the present invention to provide a new and improved variable orifice plate for use in a coal pipe

connected to supply fuel burning apparatus and more particularly, to provide a new and improved multiple pipe coal supply system for a furnace provided with plural streams of coal and primary air having variable orifice plates in accordance with the present invention installed therein for providing on-line balancing of coal flow to multiple burners.

Yet another object of the present invention is to provide a new and improved coal supply system for an existing or new multiple burner furnace which includes a new and improved orifice plate in each coal pipe for on-line adjusting and balancing coal flow to respective burners.

Still another object of the present invention is to provide a new and improved coal supply system of the character described having pressure taps before and after each orifice plate to measure changes in pressure drop.

Another object of the present invention is to provide a new and improved coal pipe orifice plate apparatus which does not require dismantling of existing coal piping for installation.

Still another object of the present invention is to provide a new and improved coal pipe orifice plate which is readily adjustable to compensate for wear and abrasion, which requires no special tools to operate, which has a removable handle to prevent unintended operation, which has a pressure-tight leak proof seal, which does not tend to accumulate a build up of pulverized coal and which may be constructed of heat and wear resistant material.

Yet another object of the present invention is to provide a new and improved coal pipe orifice plate which can be installed in a neutral position parallel to the flow axis of a coal pipe with a zero pressure drop before testing and set up is commenced to provide a fail safe starting condition.

Still another object of the present invention is to provide a new and improved coal pipe orifice plate which is supported from one side of a coal pipe rather than from two opposite sides and which may be positively locked in a selected position chosen from a plurality of different positions available.

Another object of the present invention is to provide a new and improved coal pipe orifice plate that can be used in conjunction with all types of coal pulverizers.

BRIEF SUMMARY OF THE PRESENT INVENTION

The foregoing and other objects and advantages of the present invention are accomplished in a new and improved flow control apparatus for a coal pipe containing a stream of primary combustion air carrying pulverized solid fuel particles, including a frame sealingly secured to an outside surface of the coal pipe around a window opening formed on one side of the pipe. A circular, single piece, annular orifice plate having an orifice opening at the center is supported for pivotal movement in the coal pipe on a spindle extending radially outwardly from an edge on one side of the orifice plate and out through the window opening.

A bearing sleeve for supporting the spindle for rotating movement about a spindle axis extending transversely of the coal pipe across the center is carried on a mounting plate which closes off the frame.

A removable handle is mounted on an outer end of the spindle for rotating the orifice plate in the coal pipe to vary the effective flow cross-section of the orifice opening to control the flow of coal and primary combustion air.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the present invention, reference should be had to the following detailed description

taken in conjunction with the drawings, in which:

FIG. **1** is a sectional and elevational view of a furnace and fuel supply system in accordance with the features of the present invention;

FIG. **2** is an enlarged, fragmentary, elevational view of a coal pipe with a variable orifice plate in accordance with the present invention installed therein of the furnace;

FIG. **3** is a fragmentary, longitudinal cross-sectional view taken substantially along lines **3**—**3** of FIG. **2**; and

FIG. **4** is a fragmentary, transverse cross-sectional view taken substantially along lines **4**—**4** of FIG. **2**.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

Referring now more particularly to the drawings, in FIG. **1** is illustrated a new and improved furnace and fuel supply system constructed in accordance with the features of the present invention and referred to generally by the reference number **10**.

The furnace and fuel supply system **10** includes an upstanding furnace **12** for burning pulverized coal or other fossil fuels, which fuels may be supplied from a storage system including a hopper **14** in a case when coal is used as fuel, or in tanks, pipelines, etc. (not shown) in cases when other fossil fuels are used.

Coal from the hopper **14** flows down through an outlet in communication with an inlet or feed chute **16** of a drum type coal feeder **18**. The feeder **18** is driven by a variable speed drive unit **20** to provide an appropriate fuel feeding rate as controlled by an automatic fuel feed control **22** which is set to respond to the furnace demand for fuel.

Coal from the drum type feeder **18** flows down an outlet chute **24** through a vertical coal feed chute **25** to the inlet side of a coal pulverizer **28** in which the lumps of coal are broken down to a fine powder or dust for burning in the furnace **12**. Primary combustion air for the furnace **12** is supplied through a windbox **30** on side walls **32** of the furnace **12**. A fan or blower **26** directs primary air and coal into the pulverizer **28**. Secondary air supplied from the windbox **30** enters the interior of the furnace **12** through openings **44** in side wall sections **46** of the furnace opening immediately surrounding coal nozzles **60** which supply fuel for the furnace.

A secondary air supply duct system **34** provides secondary air to the windbox **30** and includes a fan or blower **35** having an outlet connected to a duct **37** feeding the windbox. Primary combustion air is taken from the windbox **30** through a shut-off damper valve **40** and is directed into the coal feed chute via branch ducts **38** and **39**. Below the windbox **30**, the furnace **12** includes inwardly and downwardly sloping wall sections **48** adjacent a lower end **50** of a turbulent combustion chamber **42**.

The primary air flow in the duct **38** from the windbox **30** is modulated by a suction control damper **52** which is driven and controlled by a suction controller **54** having a sensor downstream of the damper. The air flow in the duct **39** is modulated by an air temperature damper **56** driven and controlled by a air temperature controller **58** having a sensor on the discharge or outlet side of the coal pulverizer **26**. An alarm **57** of a visual or audible type and a temperature indicator **59** are associated with the air temperature controller **58** and the sensor circuit connected to the outlet side of the coal pulverizer **26**.

In accordance with the present invention, the furnace **12** is provided with one or more, new and improved, burners **60** constructed in accordance with the features of the present invention. Each burner **60** is centrally disposed in a burner opening **44** in the combustion chamber wall section **46** and includes a main duct or conduit section **62** having a flanged inlet **64** at an outer end secured to an outside wall **66** of the windbox **30** around a circular opening **68** provided therein in coaxial alignment with an associated burner opening **44** in the combustion chamber wall section **46**. The inlet flange **64** of the burner **60** is connected to a flanged elbow **70**, which in turn is connected to a coal/air pipe **72** for supplying a controlled flow of primary combustion air and pulverized coal to the burner.

Each coal pipe **72** is supplied with primary combustion air which carries the pulverized coal from an outlet duct or section **74** of the coal mill or pulverizer **26**. The outlet duct **74** is connected to a transition section **76** having plural outlets, each of which is connected to an air/coal control damper **78** for modulating the flow of primary combustion air and pulverized coal carried thereby to the burner **60** via a coal pipe **72**. The air/coal control dampers **78** are controlled and interconnected with the automatic fuel feed controller **22** which controls the drum type coal feeder **18** as previously described.

Upstream of the air/coal dampers **78** each coal pipe **72** is provided with a variable orifice control plate apparatus **80**, adjustable to vary the effective cross-sectional flow area through each pipe to more precisely balance and control the amount of primary air and pulverized coal supplied to each burner **60** of the furnace **12**. Upstream of the variable orifice control plate apparatus **80**, each coal pipe **72** is provided with a shut-off valve **82** for cutting off the supply of primary combustion air and pulverized coal to the furnace **12**.

Referring now more particularly to FIGS. **2**, **3** and **4**, the variable orifice plate control apparatus **80** is adapted to be rapidly installed on existing coal pipes **72** without requiring the dismantling thereof and, of course, is readily installed in new coal piping systems. The apparatus includes a rectangular frame **84** made up of upper and lower angle members **86** and **88**, joined at upper and lower ends to opposite side frame angle members **90**. The frame **84** is mounted on one side of the coal pipe **72** to surround the edges of a rectangular-shaped window **72***a* cut from the wall of the coal pipe, usually with a cutting torch or saw.

The angle frame members have flanges **86***a*, **88***a* and **90***a* joined to the wall of the coal pipe **72** by welding **92** extending around the window **72***a* providing a gas tight seal. The angle frame members include face flanges **86***b*, **88***b* and **90***b* at right angles to the flanges **86***a*, **88***b* and **90***b*, respectively, which lie in a common plane spaced outwardly of the coal pipe **72** generally parallel of a longitudinally extending, central flow axis **94**. The longitudinal flow axis **94** is intersected at the center of the coal pipe **72** by a radially outwardly extending transverse spindle axis **96** at right angles thereto which is positioned at the center of the rectangular frame **84** as best shown in FIGS. **3** and **4**.

In accordance with the present invention, an annular orifice plate **98** formed of heat and abrasion resistant metal plate is supported in the coal pipe **72** for pivotal movement about the spindle axis **96** between selected different angular positions relative to the coal pipe flow axis **94** for controlling the flow of primary combustion air and coal flowing in the coal pipe.

The annular orifice plate **98** has a circular outer peripheral edge with a diameter slightly less than the inside diameter of the coal pipe **72** as best shown in FIG. **4**. The orifice plate **98** is formed with a smaller diameter orifice opening **100** at

the center through which a flowing stream of primary air and coal in the coal pipe **72** passes. Because the outer diameter of the orifice plate **98** is less than the inside diameter of the coal pipe **72**, some of the primary air and coal stream will flow around the outer periphery of the orifice plate adjacent the inside wall surface of the coal pipe even when the orifice plate is positioned at right angles to the flow axis **94**.

The orifice plate **98** is supported from a side edge portion thereof by a spindle **102** having an inner end joined to a radially slotted out edge portion of the orifice plate. The spindle **102** is supported for rotation about the axis **96** in a bearing sleeve **104** extending inwardly toward the window opening **72***a* of the coal pipe from an apertured, rectangular, mounting plate **106** secured to the flanges **86***b*, **88***b* and **90***b* by a plurality of bolt and nut assemblies **108**. The mounting plate **106** and the bearing sleeve **104** which is welded thereto are removable by loosening up the bolt and nut assemblies **108** and accordingly, the orifice plate **98** can be easily removed for inspection, repair and replacement when necessary.

A space **110** (FIG. **3**) between the window opening **72***a* and the mounting plate **106** may be filled with a box-like channel-shaped filler element **112** which is secured to the mounting plate by welding as best shown in FIG. **3**. These intermediate level nut and bolt assemblies **108** are also used to attach an apertured, square-shaped outer stiffening plate **114** at the center of the mounting plate **106**. An O-ring seal **116** is provided on the spindle **102** between the mounting plate **106** and the facing inside surface of the stiffening plate **114** to provide a gas tight seal. The stiffening plate **114** is provided with a threaded positioning aperture **114***a* (FIG. **3**) offset radially outwardly from a central spindle aperture. The positioning aperture **114***a* is designed to receive a position securing cap screw **118** for securing the orifice plate **98** and spindle **102** in a selected angular position relative to the flow axis **94** of the coal pipe **72**.

An outer end portion of the spindle **102** is supported in an outer sleeve **120** which is mounted on a positioning plate **122** having a central aperture for the spindle, and a plurality of position setting apertures **122***a*, **122***b*, **122***c*, etc., spaced radially outwardly of the spindle at different angles representing different angular positions of the orifice plate **98** relative to the flow axis **94** of the coal pipe **72**. A handle **124** extends through the outer sleeve **120** and an aperture in the outer end portion of the spindle **102** for rotating the orifice plate **98** and the positioning plate **122** to a selected angular position in the coal pipe **72** wherein a particular aperture **122***a*, **122***b*, **122***c* on the plate **122** is aligned with the threaded positioning aperture **114***a* on the stiffening plate **114**. The handle **124** may be removed by withdrawing the handle longitudinally from the outer sleeve **120** and the spindle **102** to prevent unwanted, unintended position changing after a position is selected and the locking cap screw **118** is secured in place.

It will thus be seen that the angular position of the orifice plate **98** relative to the flow axis **94** of the coal pipe **72** is adjustable and lockable in selected positions to provide the desired throttling action on the stream of flowing primary combustion air and coal in the coal pipe. By changing the angular position, the effective flow cross-section in the coal pipe **72** around the outer edges of the orifice plate **98** and through the central orifice opening **100** is changed to provide balanced fuel flow to each of the burners **60** in the furnace **12**. When the orifice plate **98** is positioned at right angles to the flow axis **94** (solid lines—FIGS. **2**, **3** and **4**) a maximum throttling action is obtained and the amount of pressure drop can be measured instantly after a change is made by means of manometers **126** and **128** upstream and downstream of the orifice plate.

Adjustment and changes of the angle of the orifice plate **98** in the coal pipe **72** can be accomplished on-line while the furnace **12** is in operation and results of the changes are known immediately so that orifice plates **98** for each burner **60** can be individually tuned to provide the most efficient furnace operation. It should also be noted that on an initial operational start up after installation of an orifice plate apparatus **84**, the orifice plate **98** can be positioned in an in-line or neutral state, parallel to flow axis **94** (zero pressure drop) before testing and setup begin to provide a fail safe starting point.

Installation of the orifice plate assemblies **84** in existing coal pipes **72** is made simpler because the orifice plates **98** are supported in cantilever arrangement on the spindles **102** from one rather than both sides of the coal pipe. Only a single window opening **72***a* on one side of a coal pipe **72** need be made and dismantling of the coal pipe is not required as with other types of two point support axle systems. Moreover, the unique frame **84** and mounting plate **106** in combination permit rapid access to the orifice plate **98** and spindle **102** for servicing, removal and replacement when necessary.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. Thus, it is to be understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described above.

What is claimed and desired to be secured by Letters Patent of the United States is:

1. Flow control apparatus for a coal pipe containing a stream of primary combustion air carrying pulverized solid fuel particles, comprising:

frame means sealingly secured to an outside surface of the coal pipe around a window opening formed on one side of the pipe;

an orifice plate having an orifice opening at the center supported for pivotal movement in said coal pipe on a spindle extending radially outwardly from an edge on one side of said plate through said window opening;

bearing means for supporting said spindle for rotating movement about a spindle axis extending transversely of the coal pipe across the center thereof;

mounting plate means for closing off said frame means and supporting said bearing means mounted thereon; and

handle means adjacent an outer end of said spindle for rotating the same to vary the effective flow cross-section of said orifice opening in the coal pipe.

2. The apparatus of claim **1**, wherein:

said frame means is formed of angle elements having a rectangular-shaped peripheral flange spaced outwardly of and around said window opening for receiving said mounting plate means.

3. The apparatus of claim **1**, wherein:

said orifice plate and spindle are formed of heat and abrasion resistant metal.

4. The apparatus of claim **1**, wherein:

said mounting plate means includes inner bearing means extending inwardly thereof toward said window opening supporting said spindle for rotating movement.

5. The apparatus of claim **1**, wherein:

said bearing means includes a base extending radially outward of said spindle axis and mounted on said

mounting plate means for movement to a selected one of several rotative positions thereon.

6. The apparatus of claim **5**, including:

lock means interconnecting said base and said mounting plate means for securing said base in a selected rotative position on said mounting plate means.

7. The apparatus of claim **1**, including:

O-ring seal means between said spindle and said bearing means.

8. The apparatus of claim **1**, wherein:

said handle means is detachably mounted on said spindle.

9. The apparatus of claim **1**, including:

means for measuring static pressure of said stream at position upstream and downstream of said window opening.

10. The apparatus of claim **1**, including:

filler plate means in said frame means spaced inwardly of said mounting plate means adjacent said window opening.

11. The apparatus of claim **1**, wherein:

said orifice plate has an edge portion formed with a diametrical slot for receiving an end portion of said spindle.

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